**United States Department of Agriculture** **Forest Service** **R3 Regional Office**

**333 Broadway SE**
**Albuquerque, NM 87102**
**FAX (505) 842-3800**
**V/TTY (505) 842-3292**

**File Code:** 3420 **Date:** August 25, 2005
**Route To:**

**Subject:** Douglas-fir beetle activity on the San Francisco Peaks

**To:** District Ranger, Peaks RD, Coconino NF

Jim Rolf, Silviculturist on the Peaks Ranger District, Coconino NF, requested our Forest Health Protection office examine the San Francisco Peaks area for Douglas-fir beetle activity. Therefore, during the week of July 11, 2005, Melissa Fischer and I conducted ground surveys near Forest Service Roads 516 (Snowbowl Road) and 9123J (Bear Jaw & Abineau Trailheads) to determine the level of past and current Douglas-fir beetle activity. I describe in this report background information on Douglas-fir beetle biology and outbreak dynamics, Douglas-fir beetle activity observed in the areas surveyed, and management strategies to minimize bark beetle impacts.

## *Background information on Douglas-fir Beetle*

Douglas-fir beetle (*Dendroctonus pseudotsugae*) is found throughout western North America and has one generation per year (Schmitz and Gibson 1996). In the Rocky and Cascade Mountains of the western US, initial adult flights vary from year to year with location and weather, but most new attacks take place in the spring or early summer (Furniss and Carolin 1977). Developing brood overwinter mainly as adult beetles, but also as larvae. Overwintering larvae complete their development and emerge as adults in the mid- to late-summer. Typically, late-season attacks account for less than 20 percent of all attacks in one season.

Currently infested Douglas-fir trees are identified by the presence of rust-colored boring dust (frass) in the crevices of the bark, on spider webs on the lower bole, or around the base of trunks (***Figure 1***). Sometimes streams of pitch will be present on the mid-bole which indicates where initial beetle attacks occurred. Trees having "pitch streamers" are


***Figure 1.*** *New attacks of Douglas-fir by Douglas-fir beetle are indicated by the presence of rust-colored boring dust in the crevices of bark, on spider webs (top left), or around the base of trees. Adults are dark brown to black with reddish elytra and 4.5 to 7 mm long (top right). Larval feeding galleries run perpendicular to the vertical egg galleries (bottom right).*

sometimes unsuccessfully attacked and may survive. Pitch tubes, which are a characteristic sign of bark beetles attacking pine species, are rarely seen on Douglas-fir trees. Needles of successfully attacked trees begin to fade to a sorrel and then reddish color several months to a year after the tree was initially attacked.

During endemic populations, beetles typically attack trees that have been weakened by some stressing agent. These agents can be abiotic (such as drought and fire) or biotic (overstocking causing competition, diseases, defoliation) (Furniss et al. 1979, Schmitz and Gibson 1996, Ryan and Amman 1996). In addition, Douglas-fir beetle will breed in windthrown trees or large diameter logging debris. Where abundant susceptible host material is present, beetle populations can increase rapidly and spread to adjacent green, standing trees. The duration of Douglas-fir beetle outbreaks can be quite variable, lasting from two to several years. Those outbreaks of longer duration are typically associated with extended drought.

Based on studies in the Rocky Mountains, Douglas-fir beetle preferentially attack large, old trees in dense stands with a high Douglas-fir component (Furniss et al. 1981, Negrón 1998, Negrón et al. 1999, McMillin and Allen 2003). Stand hazard rating can be calculated using these stand variables (Steele et al. 1996, ***Table 1***).

***Table 1.*** *Stand hazard rating for Douglas-fir beetle (Steele et al. 1996). To determine the hazard rating for a given stand, assign value for each stand condition, sum between conditions, and multiply by percentage of Douglas-fir in stand.*

| Hazard value | Average Age of Host (years) | Average DBH of Host | Stand Basal ($ft^2$/acre) |
|---|---|---|---|
| 3 | >120 | > (14 in) | > 250 |
| 2 | 80-120 | >10-14 | 120-250 |
| 1 | <120 | 9-10 | <120 |

## *Douglas-fir Beetle activity in the San Francisco Peaks*

Based on aerial detection surveys and ground observations, Douglas-fir beetle activity in the San Francisco Peaks has been building over the past few years. Scattered small pockets of tree mortality (1-3 dead trees per pocket) were detected beginning in 2001; primarily on trees severely infected by Douglas-fir dwarf mistletoe (***Figure 2***) and around the 2001 Leroux Fire. The severe drought in 2002 and 2003 likely contributed to increases in beetle populations by compromising host defenses and spots of greater than 5 to 10 dead trees were observed.

## *Survey methods*

A combination of variable radius plots and tree mortality surveys were used to obtain more detailed information on forest stand conditions, the numbers of trees being killed, and the relative dynamics of Douglas-fir beetle activity on the San Francisco Peaks.

**Site Descriptions.** Two general areas were selected for collecting information on Douglas-fir beetle activity. The first area was on the southwest side of the San Francisco Peaks adjacent to the Snowbowl Road (FS Road 516) in which five sites were chosen to install plots and tree

mortality surveys. The second area was on the north side of the Peaks (Forest Service Road 9123J) in the vicinity of Bear Jaw and Abineau Trailheads. Both of these areas have few roads, limited access, and/or are adjacent to Kachina Peaks Wilderness.

***Figure 2.*** *Douglas-fir mortality on the San Francisco Peaks. Douglas-fir beetle frequently attacks Douglas-fir heavily infected with dwarf mistletoe while populations are low (left), but will attack apparently healthy trees during building or high population levels (right).*

**Variable Radius Plots**. At a selected site, one variable radius plot was arranged on each corner of a square having five chains (100 m) per side. A 20 Basal Area Factor (BAF) prism was used to determine all "in" trees within the plot. Tree species, diameter at breast height (DBH), status (live, dead and estimated date of bark beetle attack), and dwarf mistletoe infection ratings (Douglas-fir and ponderosa pine) were recorded on all trees. If a tree was found to have been attacked by bark beetles, the date of attack was recorded as currently infested (CY), attacked 1 year ago, 2 years ago, or 3 or more years ago. Date of attack was determined by examining foliage fading and retention, presence of frass and/or pitch, and small branch retention (Negrón 1998). Tinnin's (1998) 6-class broom volume rating (BVR) was used to decide the level of dwarf mistletoe infection on Douglas-fir (*Arceuthobium douglasii*). The Hawksworth 6-class rating system was used to determine the level of dwarf mistletoe (*A. vaginatum* subsp. *cryptopodum*) infection on ponderosa pine (Hawksworth 1977). Average stand data were calculated based on the average of four plots per site. Interactions between Douglas-fir beetle and dwarf mistletoe infection rates were based on data pooled across all seven sites.

**Tree mortality surveys.** Surveys of tree mortality were conducted between each of the four variable radius plots described above. Surveys were one chain (20 m) wide by five chains (100) long for a total area of ½ acre per side of the square. All Douglas-fir trees were examined for attack by Douglas-fir beetle. Attacks were tallied by the same date categories used in the variable radius plots. The average number of trees killed per acre by attack date was calculated from the average of four surveys per site. Only data on Douglas-fir damage and mortality rates are presented.

## *Survey results and discussion*

Surveyed stands were characterized by relatively large diameter, mixed tree species containing moderately high total basal area (***Table 2***). On average, Douglas-fir made up approximately one-third of the tree mix and was primarily comprised of large trees growing at relatively low densities. Douglas-fir was a greater component of stands along Snowbowl Road than on the north side of the Peaks. A direct comparison of hazard ratings by site or area using Steele et al.'s (1996) rating system was not feasible as tree age was not determined; however, based on the

large mean DBH and moderately high basal area, coupled with the dwarf mistletoe infection, trees in most sites would probably be in a moderate risk category. With the ongoing drought conditions, and increasing beetle populations, these trees growing in these areas are at even greater risk.

***Table 2.*** *Stand characteristics on the San Francisco Peaks based on the average of four 20 BAF variable radius plots per site. Column headings: TOTAL BA = Total Basal Area ($ft^2$/ac), DF BA = Douglas-fir Basal Area ($ft^2$/ac), QMD = Quadratic Mean Diameter (inches), DF QMD = Douglas-fir Quadratic Mean Diameter (inches), TPA = Trees per Acre, DF TPA = Douglas-fir Trees per Acre, and % DF = percentage of tree stems being Douglas-fir.*

| SITE NUMBERS | TOTAL BA | DF BA | QMD | DF QMD | TPA | DF TPA | % DF |
|---|---|---|---|---|---|---|---|
| **Snowbowl Road** | | | | | | | |
| 1 | 135 | 45 | 18.8 | 17.7 | 69.8 | 26.3 | 33.3 |
| 2 | 220 | 60 | 16.9 | 21.1 | 141.3 | 20.5 | 27.3 |
| 3 | 135 | 45 | 13.7 | 13.9 | 131.5 | 42.8 | 33.3 |
| 4 | 215 | 95 | 17.0 | 19.7 | 136.8 | 45.0 | 44.2 |
| 5 | 170 | 75 | 19.0 | 18.1 | 86.1 | 42.0 | 44.1 |
| Mean | 175 | 64 | 17.1 | 18.1 | 113.1 | 35.3 | 36.4 |
| Standard Deviation | 41.4 | 21.3 | 2.1 | 2.7 | 32.8 | 11.1 | 7.5 |
| **FSR 9123J** | | | | | | | |
| 6 | 215 | 25 | 16.2 | 18.1 | 151.1 | 13.9 | 11.6 |
| 7 | 265 | 85 | 19.9 | 25.2 | 122.5 | 24.6 | 32.1 |
| Mean | 240 | 55 | 18.0 | 21.6 | 136.8 | 19.3 | 21.9 |
| Stand Deviation | 35.4 | 42.4 | 2.7 | 5.0 | 20.2 | 7.6 | 14.5 |

More than 60 percent of the Douglas-fir trees having a dwarf mistletoe BVR of four or greater had been attacked by Douglas-fir beetle (***Figure 3***). Less than 30 percent of trees having a BVR of two or less were attacked by Douglas-fir beetle. Whereas trees having more severe dwarf mistletoe infections were attacked usually 2 or more years ago, many of the low to moderately infected trees were attacked this year or last year.

In addition to more severely dwarf mistletoe infected trees being attacked more often by Douglas-fir beetle, the beetle seemed to prefer the larger diameter classes of trees within most BVR categories (***Figure 4***). This apparent preference was particularly noticeable at BVR ratings of 3 or greater. Based on all BVR categories combined, the mean DBH of attacked Douglas-fir trees was 23.1 inches, while the mean DBH of trees not attacked by Douglas-fir beetle was 15.6 inches. This preference for large diameter trees is consistent with previous studies on Douglas-fir beetle (Furniss et al. 1981, Shore et al. 1999).

Dwarf mistletoe BVR did not appear to vary by tree diameter (***Figure 4***). Many of the large diameter trees were observed to be severely infected in the bottom and mid crown levels, but were essentially dwarf mistletoe free in the top one third of the crown. Conversely, some of the smaller diameter trees may be infected with dwarf mistletoe, but brooms have not yet formed on branches.

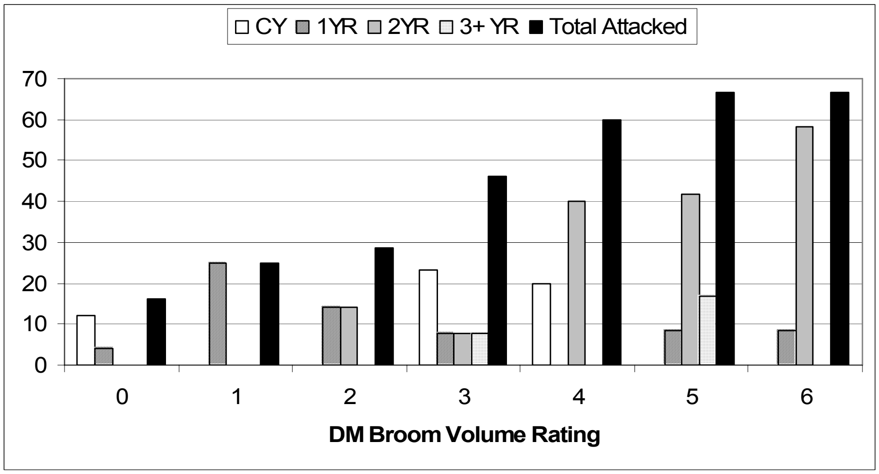


***Figure 3***. *Percentage of Douglas-fir attacked by Douglas-fir beetle categorized by dwarf mistletoe broom volume rating (BVR) on the San Francisco Peaks. Within each BVR category, attacked trees are separated by the year in which they were attacked relative to 2005.*

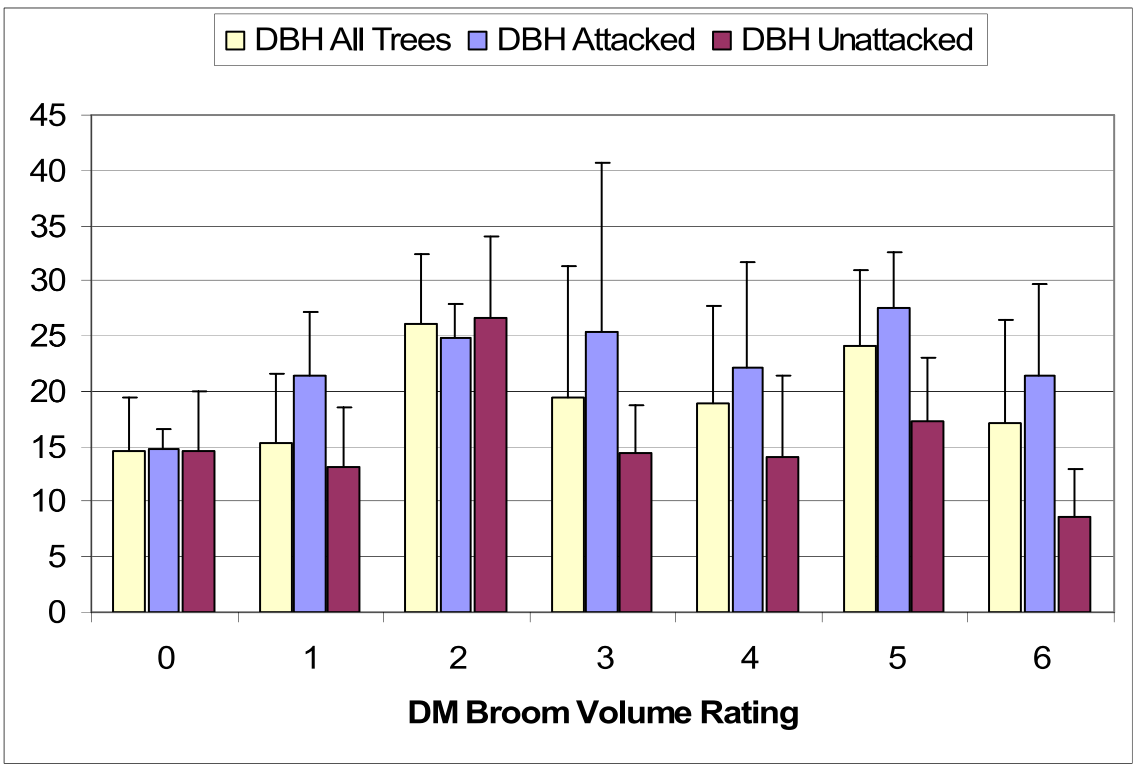


***Figure 4***. *Mean tree diameter at breast height (DBH) in inches of all Douglas-fir trees, Douglas-fir trees attacked, and Douglas-fir trees not attacked by Douglas-fir beetle categorized by dwarf mistletoe broom volume rating (BVR) on the San Francisco Peaks. Lines above dbh bars indicate + stand deviation of the means.*

Based on the cruise surveys for Douglas-fir beetle-caused tree mortality, 13 to 14 Douglas-fir trees have been killed per acre over the last few years (***Table 3***). In the Snowbowl Road area there seems to be an increasing amount of beetle activity as there were more than twice as many trees killed per acre in 2005 compared with trees killed 3 or more years ago. On the north side of the San Francisco Peaks, the level of beetle activity appears to be declining with most of the Douglas-fir tree mortality occurring 2 or more years ago. Because there were only slightly more than 19 Douglas-fir trees growing per acre on the north side of the Peaks, and the majority (>70 percent) of trees having already been killed, a sustained Douglas-fir beetle outbreak is not likely in this area. In contrast, only approximately 38 percent of the Douglas-fir trees along Snowbowl Road have been killed and the area will probably see continued high mortality in the coming year. It is important to keep in mind that additional tree mortality may have occurred after the cruise surveys took place, and therefore the reported numbers should be considered conservative.

Another factor potentially affecting the susceptibility of Douglas-fir trees on the San Francisco Peaks is root disease (Armillaria root rot, Tomentosus root disease, and Schweinitzii root and butt rot). Root disease fungi have been observed in other areas on the San Francisco Peaks infecting Douglas-fir trees that were also infected with dwarf mistletoe and subsequently attacked by Douglas-fir beetle (M.L. Fairweather, personal communication). Root disease is referred to as "a disease of the site" because the fungi colonize dead and dying trees and remain in dead roots and soils for many years. Root disease or decay fungi spread from roots of diseased trees to those of healthy ones. They start in a tree or stump and spread slowly outward in all directions, resulting in a slowly enlarging group of dying and dead trees. Additional surveys are needed to determine the intensity of root disease on the Peaks and its potential interaction with Douglas-fir beetle and dwarf mistletoe.

***Table 3.*** *Douglas-fir beetle activity determined by cruise surveys on the San Francisco Peaks. The mean number of trees per acre currently infested, attacked 1 year ago, 2 years ago, 3 or more years ago, and the total number attacked are shown.*

| *SITE NUMBERS* | *Current* | *1YR OLD* | *2YR OLD* | *3+YR OLD* | *TOTAL* |
|---|---|---|---|---|---|
| **Snowbowl Road** | | | | | |
| 1 | 8.5 | 8 | 0 | 0.5 | 17 |
| 2 | 4 | 1 | 8 | 5 | 18 |
| 3 | 1 | 1 | 2.5 | 1.5 | 6 |
| 4 | 3 | 7 | 2 | 0 | 12 |
| 5 | 12 | 0 | 2 | 0 | 14 |
| Mean/acre | 5.7 | 3.4 | 2.9 | 1.4 | 13.4 |
| Standard Deviation | 4.47 | 3.78 | 3.01 | 2.10 | 4.77 |
| **FSR 9123J** | | | | | |
| 6 | 0.5 | 0 | 5.5 | 2.5 | 8.5 |
| 7 | 2.5 | 2.5 | 11 | 4.5 | 20.5 |
| Mean/acre | 1.5 | 1.25 | 8.25 | 3.5 | 14.5 |
| Standard Deviation | 1.41 | 1.77 | 3.89 | 1.41 | 8.49 |

### *Other observations*

Scattered Douglas-fir mortality was observed while driving around other areas of the San Francisco Peaks. For example, relatively high levels of mixed conifer (Douglas-fir and white fir) mortality were seen on the north side of Little Elden Mountain and Dry Lake Hills. Also, high levels of corkbark fir mortality caused by the western balsam bark beetle (*Dryocoetes confusus*) were observed in our plots and mortality surveys on the north side of the San Francisco Peaks. Sixty percent of the corkbark fir in the variable radius plot of sites 6 and 7 had been killed. All of this mortality was 2 or more years old.

### *Treatments to reduce Douglas-fir beetle activity*

Strategies to minimize impacts caused by Douglas-fir beetle can be divided into either short term (individual tree protection or suppression actions) or long term (silvicultural or preventative) approaches.

**Suppression.** Most suppression or direct control actions have involved sanitation harvesting of currently infested trees. Sanitation harvesting should be completed before beetle emergence in late spring. The goal of direct control is to reduce the local population of beetles in the short-term, and is generally only effective when populations are beginning to increase from an endemic phase. It is also important to keep in mind that sanitation harvesting does not affect the overall long-term susceptibility of a stand.

Another option for reducing local populations of Douglas-fir beetle is to mass trap adult beetles with funnel traps, bait standing trees or felled trap trees (Knopf and Pitman 1972, Ross and Daterman 1997a, 1997b; Thier 1997). As with sanitation treatments, this approach is generally most effective during small to increasing population levels and when combined with other management treatments. Managers should be aware that Douglas-fir trees nearby baited trees or traps are also frequently attacked. However, this spillover into unbaited trees works to concentrate beetles within specific areas and can be advantageous if the baiting or trapping is part of a sanitation harvest or treatment strategy. Also, baited or felled trap trees that are successfully attacked must be removed from the host type or beetles destroyed through burning, debarking or other means prior to emergence next spring.

**Individual tree protection**. The anti-aggregation pheromone (3-methylcyclohex-2-en-1-one [MCH]) serves to disrupt aggregation behavior of beetles (Schmitz and Gibson, 1996). MCH has been used experimentally to reduce the level of attack in high-risk areas (Ross and Daterman 1994, 1995) and is now being used operationally to protect localized areas from being attacked by Douglas-fir beetle. A guide to the protocol for using MCH has been developed (Ross et al. 2001) and has been forwarded to the District.

Preventative sprays are available and effective at protecting high value Douglas-fir trees. However, because of the application cost and other concerns, spraying is typically not warranted for Douglas-fir beetle outside of landscape trees on private lands, campgrounds, administrative sites or other areas with high value trees.

**Silvicultural**. The most effective long-term strategy to minimize Douglas-fir beetle impacts is to reduce stand susceptibility to beetle infestations. Schmitz and Gibson (1996) state that the higher the proportion of trees with "susceptible" characteristics, the higher the susceptibility of

the stand to beetle attack. Silvicultural treatments that reduce stressing agents (i.e., dwarf mistletoe infection levels) and inter-tree competition for resources, will increase the vigor of residual trees and reduce overall stand susceptibility. Care should be taken when implementing silvicultural treatments in areas where root diseases are present. Maintaining a mixed species stand will help reduce overall stand level impacts caused by root disease due to differences in susceptibility to the various root disease causing pathogens.

Based on the stand conditions present, the observed levels of current Douglas-fir beetle activity, and location of this activity (areas of restricted road access and adjacent to Wilderness in some locations), there is a limited amount of work that can be implemented to mitigate further beetle impacts. In particular, on the north side of the Peaks, Douglas-fir beetle activity appears to have declined and little host type remains. Adjacent to Snowbowl Road, the anti-aggregation pheromone for Douglas-fir beetle (MCH) could be used in 2006 to protect stands or small pockets of large-diameter Douglas-fir. Maintaining these trees might be desirable from an aesthetic viewpoint and because large Douglas-fir that have or could be killed adjacent to road become hazard trees. Additional mortality of large diameter Douglas-fir in this area will continue to change the character of the visual corridor along the road. In areas where accessibility permits entry into stands, removal of heavily dwarf mistletoe-infected, large diameter Douglas-fir would likely reduce the overall stand susceptibility to Douglas-fir beetle. However, removal of such trees may pose conflicts with other management objectives on the District.

We installed baited funnel traps in June 2005 at three locations along Snowbowl Road to monitor beetle flight and to compare two different aggregation lures. The results of this study will be reported at a future date, but early observations of trap catches indicate large numbers of beetles being caught between mid-June and mid July and differences between the two lures. Use of these traps in future years may help to reduce local populations of beetles.

Funds may be available from Forest Health Protection to help mitigate impacts caused by Douglas-fir beetle in FY2006. If you have any questions regarding this assessment, please let me know. I can be reached at (928) 556-2074.

/s/ Joel D. Mcmillin
JOEL D. McMILLIN
Entomologist, Forest Health, Arizona Zone

cc:
Mailroom R3 Coconino
James Rolf
Michael Manthei
John Anhold
Debra Allen-Reid

MaryLou Fairweather
Leonard Lucero
Gene Waldrip

## *References*

Furniss, R.L. and V.M. Carolin. 1977. Western Forest Insects. USDA Forest Service Miscellaneous Publication 1339. 654 p.

Furniss, M.M., M.D. McGregor, M.W. Foiles, and A.D. Partridge. 1979. Chronology and characteristics of a Douglas-fir beetle outbreak in norther Idaho. USDA Forest Service. Gen. Tech. Rep. INT-59. 19 p.

Furniss, M.M., R.L. Livingston, and M.D. McGregor. 1981. Development of a stand susceptibility classification for Douglas-fir beetle. In: Hazard Rating Systems in Forest Insect Pest Management (R.L. Hedden, S.J. Barras J.E. Coster Tech. Coor.). USDA Forest Service General Technical Report WO-27. 169 p.

Hawksworth, F.G. 1977. The 6-class dwarf mistletoe rating system. USDA For. Serv. Res. Note RM-48. 7 p.

Knopf, J.A.E and G.B. Pitman. 1972. Aggregation pheromone for manipulation of the Douglas-fir beetle. Journal of Economic Entomology 65: 723-726.

McMillin, J.D. and K.K. Allen. 2003. Effects of Douglas-fir beetle (Coleoptera: Scolytidae) on forest overstory and understory conditions in the Rocky Mountains. Western North American Naturalist 63: 498–506.

Negrón, J.F. 1998. Probability of infestation and extent of mortality associated with the Douglas-fir beetle in the Colorado Front Range. Forest Ecology and Management 107: 71-85.

Negrón, J.F., W.C. Schaupp, Jr., K.E. Gibson, J.A. Anhold, D. Hansen, R. Thier, and P. Mocettini. 1999. Estimating extent of mortality associated with the Douglas-fir beetle in the central and northern Rockies. Western Journal of Applied Forestry 14: 121-127.

Ross, D.W. and G.E. Daterman. 1997a. Integrating pheromone and silvicultural methods for managing Douglas-fir beetle. Pages 135-145 in Proceedings: Integrating cultural tactics into the management of bark beetle and reforestation pests (J.C. Gregoire. A.M. Liebhold, F.M. Stephen, K.R. Day, and S.M. Salom, editors). USDA Forest Service General Technical Report NE-236.

Ross, D.W., K.E. Gibson, and G.E. Daterman. 1997b. Using pheromone-baited traps to control the amount and distribution of tree mortality during outbreaks of the Douglas-fir beetle. Forest Science 43: 65-70.

Ross, D.W., K.E. Gibson, and G.E. Daterman. 2001. Using MCH to protect trees and stands from Douglas-fir beetle infestation. USDA Forest Service, FHTET-2001-09. 11 p.

Ryan, K.C. and G.D. Amman. 1996. Bark beetle activity and delayed tree mortality in the Greater Yellowstone Area following the 1988 fires. In: Greenlee, Jason, ed. The Ecological Implications of Fire in Greater Yellowstone: Proceedings, Second Biennial Conf. on the Greater Yellowstone Ecosystem; 1993 Sept. 19-21, Yellowstone National Park, WY. Fairfield, WA. International Association of Wildland Fire; pp. 151-158.

Schmitz, R.E. and K.E. Gibson. 1996. Douglas-fir beetle. USDA Forest Service, Forest Insect & Disease Leaflet 5. 8 p.

Shore, T.L., L. Safranyik, M. Furguson, J. Castonguay, and W.G. Riel. 1999. Evaulation of factors affecting tree and stand susceptibility to the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae). Canadian Entomologist 131: 831-839.

Steele, R,. R.E. Williams, J.C. Weatherby, E.D. Reinhardt, J.T. Hoffman, and R.W. Thier. 1996. Stand hazard rating for central Idaho forests. USDA Forest Service General Technical Report INT-GTR-332, 29 p.

Thier, R.W. 1997. Mortality of Douglas-fir after operational semiochemical baiting for Douglas-fir beetle (Coleoptera: Scolytidae). Western Journal of Applied Forestry 12: 16-20.

Tinnin, R.O. 1998. An alternative to the 6-class dwarf mistletoe rating system. Western Journal of Applied Forestry 13: 64-65.